

CLAIMS

What is claimed is:

1. Method of identifying an object in a laser beam illuminated scene based on material types, said method comprising the steps of:

emitting a pulsed beam of laser energy, each beam pulse comprising a plurality of different discrete wavelength emission components;

illuminating a predetermined scene with said pulsed beam of laser energy;

receiving return laser pulses from objects within said illuminated scene, each return laser pulse comprising return components corresponding to the plurality of different discrete wavelength emission components;

determining spectral reflectance values for said plurality of return components of each return laser pulse;

determining a material type for each return laser pulse of said illuminated scene based on said plurality of reflectance values of the corresponding return pulse;

indexing each determined material type to a position in said illuminated scene; and

identifying an object in said illuminated scene based on material types and indexed positions thereof in said scene.

2. The method of claim 1 including the steps of:

determining a range of each return laser pulse of the illuminated scene;

associating the range of the return laser pulse with the material type thereof; and

identifying an object in said illuminated scene based on material types and corresponding indexed positions and ranges thereof in said scene.

3. The method of claim 2 wherein the step of identifying the object includes joining together material types that are of a predetermined type, adjacent to each other in position, and fall within a predetermined range bin.
4. The method of claim 2 including the step of classifying the identified object based on the material type thereof.
5. The method of claim 4 including the steps of:

determining the shape of the identified object; and

detecting a potential threat based on the material type and shape of the identified object.
6. The method of claim 5 wherein the step of detecting a potential threat includes comparing the shape and material type of the object to predetermined threat signatures.
7. The method of claim 6 including the step of prioritizing the detected potential threat based on the step of comparing.
8. The method of claim 5 including the step of including a representative image of the detected threat in a display image in accordance with its position in the illuminated scene.
9. The method of claim 5 including repeating the steps of claim 1 for each of a subsequent plurality of scenes; performing the steps of claims 2, 4, and 5 for each subsequent scene of the plurality; tracking the potential threat through the subsequent plurality of scenes; and prioritizing said threat based on the track thereof.
10. The method of claim 1 wherein the step of emitting includes the steps of:

simultaneously emitting a plurality of laser pulses of different discrete wavelengths;

and

combining the plurality of laser pulses into each beam pulse of laser energy.
11. The method of claim 1 wherein the step of illuminating includes scanning an oscillating laser beam across the predetermined scene.

12. The method of claim 1 wherein the step of determining spectral reflectance values includes the steps of:

separating each return laser pulse by wavelength into the return pulse components of different discrete wavelengths; and

determining a spectral value for each separated return pulse component.

13. The method of claim 12 including the step of: capturing a peak of each separated return pulse component as the spectral value thereof.

14. The method of claim 12 including the steps of:

determining a time of arrival of each separated return pulse component; and

determining a range of a return laser pulse based on the times of arrival of the separated return pulse components thereof.

15. The method of claim 1 wherein the step of determining a material type for each return pulse includes operating on the plurality of reflectance values of each pulse with a neural network algorithm.

16. The method of claim 1 wherein the step of determining a material type for each return pulse is performed in real time.

17. The method of claim 1 wherein the step of illuminating includes scanning an oscillating laser beam across the predetermined scene; and wherein the step of indexing includes the steps of:

determining the position of each return laser pulse in the scan of the scene;

associating said position of each return laser pulse with the material type thereof; and

indexing each determined material type based on the associated position thereof in the scan of the scene.

18. The method of claim 17 including the steps of:

scanning an oscillating laser beam across the predetermined scene from different geographical positions; and

referencing the determined positions of the return laser pulses to a common frame of reference based on said different geographical scanning positions.

19. The method of claim 17 including the steps of:

scanning an oscillating laser beam across the predetermined scene from different attitudes; and

referencing the determined positions of the return laser pulses to a common frame of reference based on said different scanning attitudes.

20. A system for identifying an object in a laser beam illuminated scene based on material types, said system comprising:

a laser source for emitting a pulsed beam of laser energy, each beam pulse comprising a plurality of different discrete wavelength emission components;

a first arrangement of optical elements disposed in a path of said pulsed beam for illuminating a predetermined scene with said pulsed beam of laser energy;

a second arrangement of optical elements for receiving return laser pulses from objects within said illuminated scene and separating each return laser pulse into return components corresponding to the plurality of different discrete wavelength emission components;

a first processing circuit for receiving said return components, determining spectral reflectance values for said plurality of return components of each return laser pulse, and generating reflectance signals representative thereof; and

a second processing circuit for receiving said reflectance signals and determining a material type for each return laser pulse of said illuminated scene based on said plurality of reflectance signals of the corresponding return pulse, said second processing circuit operative to index each determined material type to a position in said illuminated scene, and to identify an object in said illuminated scene based on material types and indexed positions thereof in said scene.

21. The system of claim 20 wherein the second processing circuit is operative to determine a range of each return laser pulse of the illuminated scene, to associate said range of the return laser pulse with the material type thereof, and to identify an object in said illuminated scene based on material types and corresponding indexed positions and ranges thereof in said scene.
22. The system of claim 21 wherein the second processing circuit is operative to identify the object by joining together material types that are: of a predetermined type, adjacent to each other in position, and fall within a predetermined range bin.
23. The system of claim 21 wherein the second processing circuit is operative to classify the identified object based on the material type thereof.
24. The system of claim 23 wherein the second processing circuit is operative to determine the shape of the identified object, and to detect a potential threat based on the material type and shape of the identified object.
25. The system of claim 24 wherein the wherein the second processing circuit is operative to detect the potential threat by comparing the shape and material type of the object to predetermined threat signatures.
26. The system of claim 25 wherein the second processing circuit is further operative to prioritize the detected potential threat based on the comparison of the shape and material type of the object to the predetermined threat signatures.
27. The system of claim 24 including a display; and wherein the second processing circuit is operative to control the display to include a representative image of the detected threat in a screen image in accordance with its position in the illuminated scene.
28. The system of claim 20 wherein the laser source comprises a plurality of lasers operative to simultaneously emit a plurality of laser pulses of different discrete wavelengths for each beam pulse of laser energy; and an optical combiner for combining each simultaneously emitted plurality of laser pulses into the corresponding beam pulse.
29. The system of claim 20 wherein the first arrangement of optical elements comprises an optical scanner for scanning an oscillating laser beam across the predetermined scene.

30. The system of claim 20 wherein the second arrangement of optical elements comprises optical elements for separating each return laser pulse by wavelength into the return pulse components of different discrete wavelengths and distributing said return pulse components along separate optical return paths; and wherein the first processing circuit comprises: a light detector disposed in each optical return path for converting the corresponding return pulse component into an electrical return pulse signal representative thereof; and a signal conditioning circuit for receiving the electrical return pulse signals and determining a spectral reflectance value for each return pulse signal.

31. The system of claim 30 wherein the signal conditioning circuit comprises a circuit for capturing a peak of each return pulse signal as the spectral reflectance value thereof.

32. The system of claim 30 wherein the signal conditioning circuit comprises a circuit for determining a time of arrival of each return pulse signal, and generating a time signal representative thereof; and wherein the second processing circuit is operative to receive the time signals for each return laser pulse and to determine a range of each return laser pulse based on said corresponding time signals thereof.

33. The system of claim 20 wherein the second processing circuit comprises a digital processor programmed with a neural network algorithm, said digital processor operative to receive the plurality of reflectance values of each laser return pulse and to determine a material type for each return pulse by processing the plurality of reflectance values of each laser return pulse with said neural network algorithm.

35. The system of claim 33 wherein the digital processor is operative to receive the plurality of reflectance values of each laser return pulse and to determine a material type for each return pulse by processing the plurality of reflectance values of each laser return pulse with said neural network algorithm in real time.

36. The system of claim 20 wherein the first arrangement of optical elements comprises an optical scanner for scanning an oscillating laser beam across the predetermined scene, said scanner coupled to said laser source and second arrangement of optical elements by fiber optic cables.

37. The system of claim 36 wherein the second processing circuit is operative to determine the position of each return laser pulse in the scan of the scene, to associate the

position of each return laser pulse with the material type thereof, and to index each determined material type based on the associated position thereof in the scan of the scene.

38. The system of claim 37 wherein the scanner is mountable on a moving platform for scanning the oscillating laser beam across the predetermined scene from different geographical locations; including means for determining said geographical locations of the moving platform; and wherein the second processing circuit is operative to reference the determined positions of the return laser pulses to a common frame of reference based on said determined geographical locations.

39. The system of claim 37 wherein the scanner is mountable on a moving platform for scanning the oscillating laser beam across the predetermined scene from different attitudes; including means for determining said different attitudes of the scanner; and wherein the second processing circuit is operative to reference the determined positions of the return laser pulses to a common frame of reference based on said determined attitudes.

40. The system of claim 20 wherein the second processing means is operative to receive reflectance signals of and determine a material type for each return pulse of a plurality of sequentially illuminated scenes, to index each material type of a scene of said plurality to a position in the corresponding scene, and to identify a common object in each scene of the plurality based on material types and indexed positions thereof.

41. The system of claim 40 wherein the second processing means is operative to determine movement of the common object between scenes of the plurality.

42. The system of claim 41 wherein the processing means is operative to track the moving object through the plurality of scenes, and to assess threat based on the track of the moving object.

43. The system of claim 20 wherein the plurality of different discrete wavelengths of the emission components are chosen from wavelengths within a near infrared band.

44. The system of claim 43 wherein the near infrared band spans approximately one to two microns.